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CONSIDERATION OF SOME HI-FI EARPHONES FOR SUBMARINE SONAR

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## SUMMARY PAGE

### THE PROBLEM

To determine the frequency response characteristics of various commercially available, as well as the standard Navy issue earphones, in order to ascertain the most efficient transducer for Sonar listening. Also of interest was the attenuation properties of each driver's circumaural cushions.

### FINDINGS

It was found that the Koss "Stereophones" were the best phones as regards overall "flatness" of response. The Koss "PRO-4A" phones are the best with respect to frequency response.

When attenuation of transient noise is considered, the Koss "PRO-4A" cushion or TRACOR "Otocup" is superior to the Navy "NAF" cushion.

### APPLICATION

The Navy H-3/ARR-3 earphones, commonly used on Sonar watch, can be excelled in performance by a number of moderately priced, commercially available units.

### ADMINISTRATIVE INFORMATION

This investigation was conducted as a part of Bureau of Medicine and Surgery Research Work Unit MF022.01.04-9004—Optimizing of Special Senses in Submarine and Diving Operations. The present report is No. 11 on this Work Unit. It was approved for publication on 30 July 1968, as Submarine Medical Research Laboratory Memorandum Report 68-14.

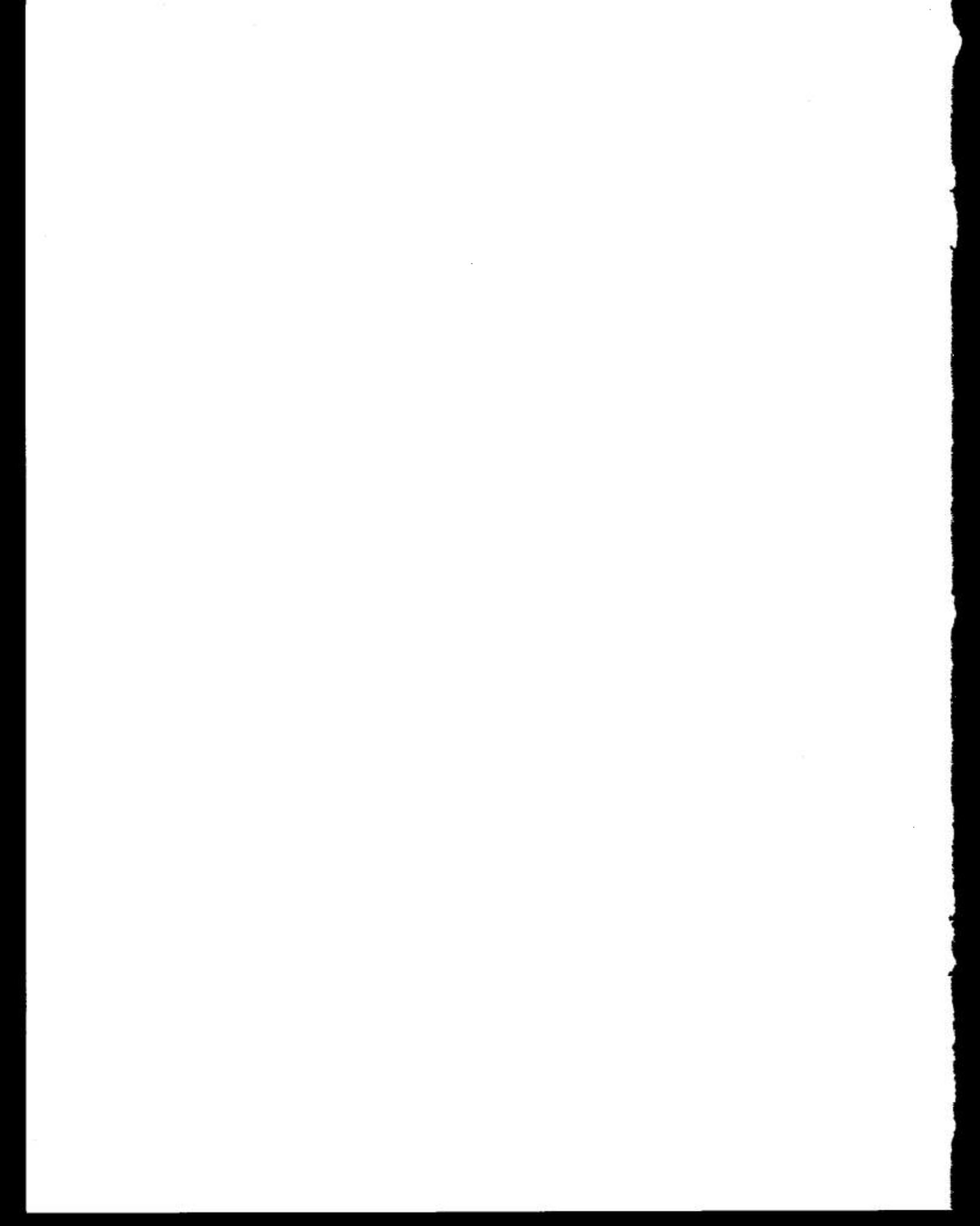
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## ABSTRACT

In order to ascertain the optimal headset unit for sonar listening, standard procedures were used to obtain the frequency response characteristics of three Navy issue H-3/ARR-3 headsets, as well as six commercially available units. Regarding the obtained functions, for overall sensitivity, the Koss "Stereophones" were superior in that they responded with superior sound pressure level (SPL) readings for the 0.5-volt constant input. With respect to overall flatness of response, the Koss "PRO-4A" phones were the superior unit. In contrast to these above headsets, the Navy H-3/ARR-3 units proved to be relatively insensitive in the most sensitive part of the audible spectrum, and exhibited unnecessary peaks between 3-8 kiloHertz (kHz).

To determine the attenuation properties of each transducer's circumaural cushions along the audible spectrum, a probe attached to a sound pressure level meter, was inserted in the external ear, both prior to wearing, and after headset was in place. These results indicated that the Navy "NAF" cushions were the most inferior in this respect, and was excelled by the TRACOR Company "Otocup" and the Koss "PRO-4A" cushion.



# CONSIDERATION OF SOME "HI-FI" EARPHONES FOR SUBMARINE SONAR

## I. INTRODUCTION

This Center has been periodically concerned with the phones proposed from time to time for sonar watchstanding.

### (a) Earphones.

Models examined in this report were all fitted with supra-aural cushions; the assistance of LCDR. C. E. Harrison, USN, of USS CAVALLA (AGSS-244) in collecting these units is acknowledged.

(1-3) 3 specimens of Standard Navy headphone H-3/ARR-3 in NAF-48490-1 oval chamois-covered cushions.

(4) Tracor, Inc., "Otocup", a supra-aural cushion incorporating a Telephonics Co. TDH-39 earphone. This combination is currently widely used in audiology practice.

(5) Beyer DT-48 earphone in a relatively small cavity cushion.

(6) Koss Electronics, Inc. "Stereophones".

(7) Koss "PRO-4A" stereophones.

(8) Stereophones (sold by Superex Electronics Corp., 4-6 Radford Place, Yonkers, N. Y. 10701) of Japanese manufacture.

(9) Knight "KN 845" stereo headset.

(10) Navy Headset No. 5965-755-4656.

### (b) Sensitivity and Frequency-Response Characteristics.

Each phone-cushion combination was centered over a Western Electric 640AA microphone imbedded flush in a solid 4x4-inch aluminum plate  $\frac{1}{2}$ " thick, the microphone protective cover flush with the plate (see Charan, K. K., et al, "Evaluation of new coupler for circumaural earphones," J. Acoust. Soc. Amer., 1965, 35, 945-955; though see Charan, K. K., et al, "Limitations on the use of circumaural earphones," J. Acoust.

Soc. Amer., 1967, 41, 713, for a discussion of the geometry of the earphone-microphone coupling at 3 kilocycles per second (kc/s) and higher.)

A 300-gram weight was applied to the earphone. The microphone output was split and led to (a) a Western Electro-Acoustic Laboratory Co. voltmeter calibrated in sound pressure level (SPL) re 0.0002 dyne per microbar and to (b) a General Radio graphic level recorder. The earphone was energized from a General Radio oscillator (output constant at 0.5 volts) coupled to the drive of the graphic level recorder so that an ink tracing of the phone's response from 0.1-20 kc/s was automatically obtained.

### (c) Attenuation of Ambient Noise Provided by Circumaural Cushions.

The tip of a "probe" microphone calibrated in our anechoic chamber was placed at the entrance to the ear canal of an average young male head, and a frequency-response graph was drawn from 0.1-20 kc/s; all units were then placed on the head in turn, and graphs drawn. The differences in dB between the reference and the unit graph were computed and taken as the cushion's protection from ambient sound.

## II. RESULTS

### (a) Sensitivity and Frequency-Response Characteristics.

No single phone exhibits both high sensitivity and flat response. Of course, in the design of transducers one is always faced with a trade-off between sensitivity and bandwidth. In the case of the standard Navy headset (see Fig. 1) a broad low-frequency peak exhibits a maximum at about 200-500 c/s, another at 4-10 kc/s, and appreciable energy is transduced even up to 20 kc/s. The sensitivity is however quite poor (only 76 dB SPL at 1 kc/s for 0.5 V to the driver), and the response is not commensurably flat.

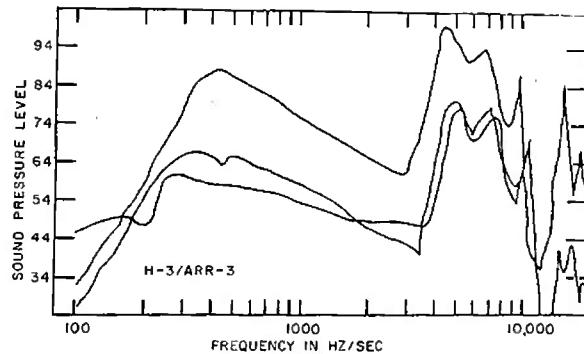


Fig. 1: Figure response characteristics of three Navy issue H-3/ARR-3 earphones mounted in NAF 48490-1 cushions. All ordinate ratings are made with reference to a 0.5 volt input to the transducer.

The American Standard audiometric unit was examined (see Fig. 2); its poor low-frequency response renders it unsatisfactory. The standard German audiometric unit was examined (see Fig. 3) but its low-frequency response was also poor.

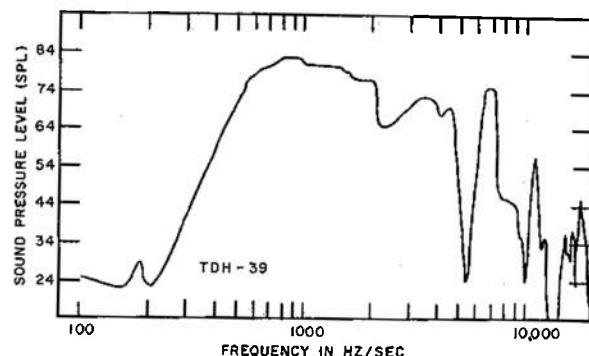


Fig. 2: Frequency response characteristics of a TDH-39 earphone mounted in a TRACOR Co. "Otocup" (0.5 volt input).

A set of unnumbered "stereophones" from Koss was examined (see Fig. 4). It has high sensitivity (134 db SPL at 1 kc/s for 0.5 V to the driver) and its low-frequency response remains high down to 100 c/s; it is rather "peaky", and its high frequencies reach noise level at 13 kc/s. Another Koss

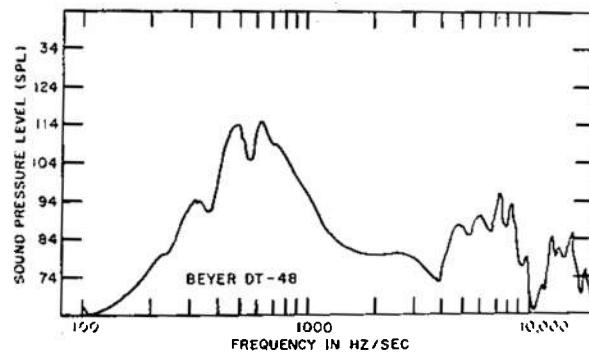


Fig. 3: Frequency response characteristics of Beyer Model DT-48 earphones mounted in circumaural cushions (0.5 volt input).

model, the PRO-4A (see Fig. 5) exhibits a superior smooth frequency-response from 0.1 - 20 kc/s, but its sensitivity is poor (91 db SPL at 1 kc/s for 0.5 V to driver).

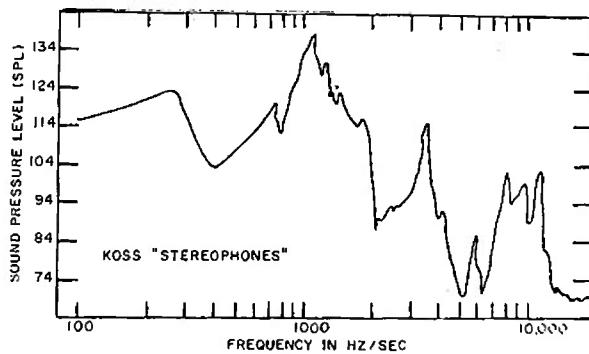


Fig. 4: Frequency response characteristics of KOSS "Stereophones" (0.5 volt input).

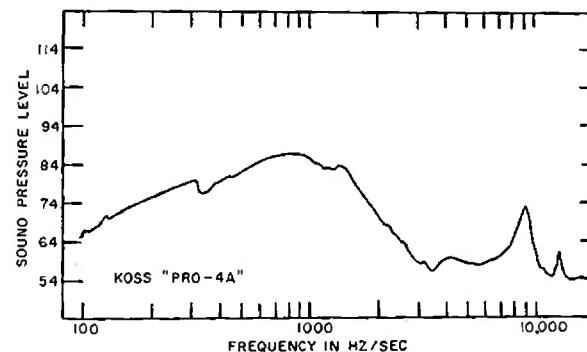


Fig. 5: Frequency response characteristics of a set of KODD "PRO-4A" stereophones (0.5 volt input).

A set of Japanese "stereophones" was available (see Fig. 6) but its high-frequency roll-off argues against its use.

A Navy headset developed for communication in high-intensity noise (see Fig. 8) is obviously unsuited for sonar work by reason of its peak at 3-4 kc/s.

A stereoset of extreme high-sensitivity for low-frequencies is the Knight (see Fig. 7), but its high-frequency roll-off and "peakiness" is extreme.

For overall sensitivity the Koss "Stereophones" are superior (Fig. 4), and for overall flatness, the Koss PRO-4A (Fig. 5). Depending upon which feature is most desirable, a choice could be made which in that regard would be superior to the current standard sonar headset.

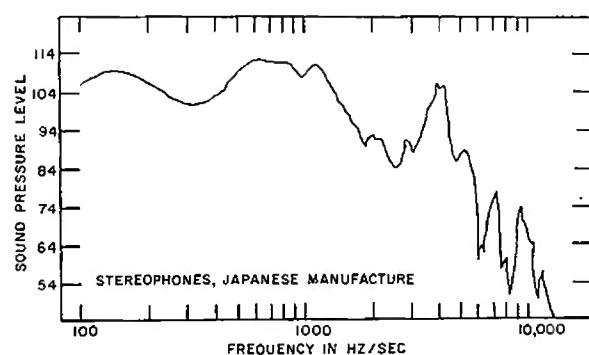


Fig. 6: Frequency response characteristics of the stereophones of Japanese manufacture (0.5 volt input).

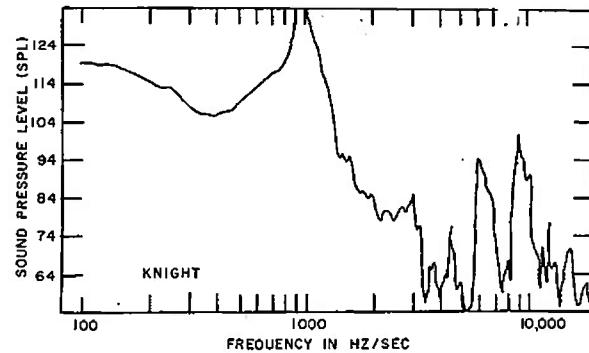


Fig. 7: Frequency response characteristics of "KNIGHT" stereophones (0.5 volt input).

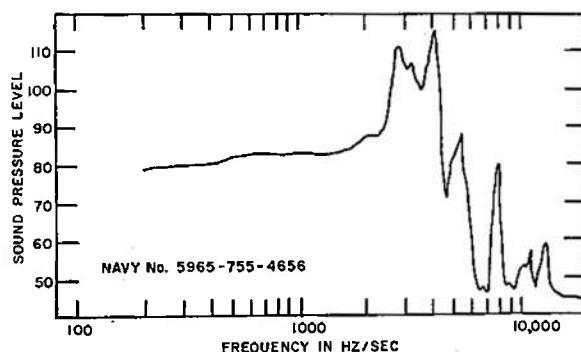


Fig. 8: Frequency response characteristics of a Navy earphone. No. 5965-755-4656, mounted in circumaural cushions (0.5 volt input).

(b) Attenuation of Ambient Noise  
Fig. 9 shows that the standard Navy

"NAF" cushion is the most inferior unit in this respect. Among the best units commercially available today which do or can incorporate an earphone are the Tracor Co. "Otocup" and the Koss cushion. Other models examined are seen in Figs. 9-10 to lie intermediate between the Navy and the Koss units.

When attenuation of background noise in the sonar shack is a factor, the Koss cushion or the "Otocup" are superior units.

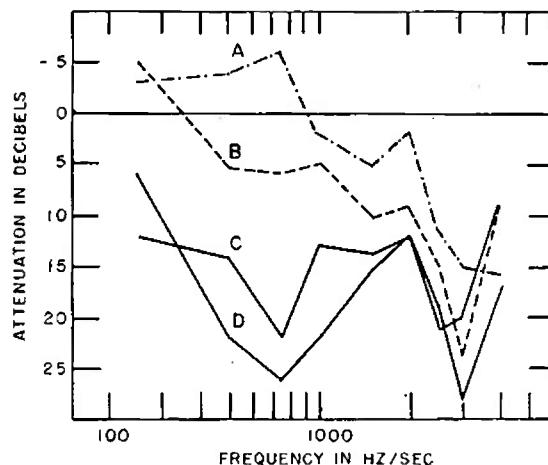


Fig. 9: Attenuation provided by four sets of circumaural cushions.

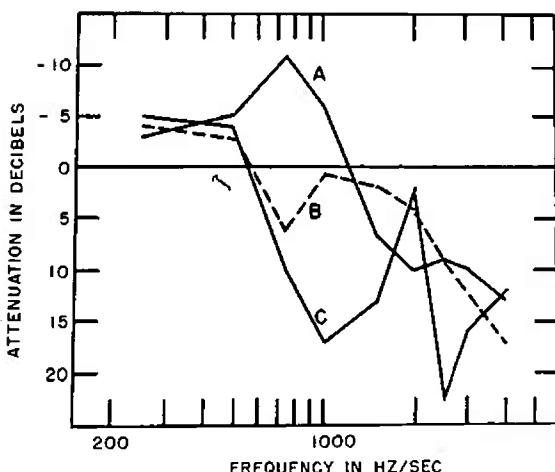


Fig. 10: Attenuation provided by three sets of circumaural cushions.

### III. DISCUSSION

A high-sensitivity earphone with flat frequency-response characteristic is within the current state of the art, by utilizing a 200-300 V polarizing voltage with a condenser microphone and using it as an earphone. Also, some experimental capacitor semi-insertion phones are in existence with very thin (0.00015-inch) gold-plated mylar diaphragms which are flat from 20-20,000 c/s. But these systems are either very expensive or not able to withstand all environmental conditions.

A wide variety of inexpensive so-called "stereo hi-fi" headsets are commercially available, and widely advertised. Our sampling of these reveals no unit which ideally fills the requirements. However, there exist units which are somewhat superior to the standard Navy headset both in sensitivity and in "peakiness".

Since our sampling is rather limited at the moment, it is concluded that the search should continue for a moderate-priced driver of acceptable sensitivity, flatness of response, and ruggedness.

Circumaural cushions definitely superior to the Navy NAF earphone cushion are commercially available and should be looked into. Some drivers can be incorporated into almost

any circumaural cushion, while some (especially those larger ones with good low-frequency response) must be built integrally into the cushion. Further study of circumaural cushions must therefore await a decision on the driver of choice; but the data in this paper indicate the degree of attenuation of ambient noise which the final design should equal or approach.

## APPENDIX

### WHAT PRICE SONAR? \*

by

CDR G. C. MERRITT, USN

CO, USS GEORGE WASHINGTON (SSBN 598) (GOLD)

You say you have a quarter million (or multiples thereof) dollar sonar unit? How effective are those dollars if your sonarmen can't hear all that this exotic equipment is giving them?

Look at the headset/earphones they are plugging into this super hi fi rig. We on WASHINGTON did and the earphones were circa Marconi wireless vintage. Nice for the Smithsonian but not what you might say were up to the state of the art.

Would you believe a readily available \$40 commercial stereo headset and suddenly the Lo Fi rig becomes hi fi? The AN/BQR-2 attenuator is now at an all time low setting and the BQR-7 is two blocked low. A reasonably cheap investment for a step improvement in performance compared to total equipment cost.

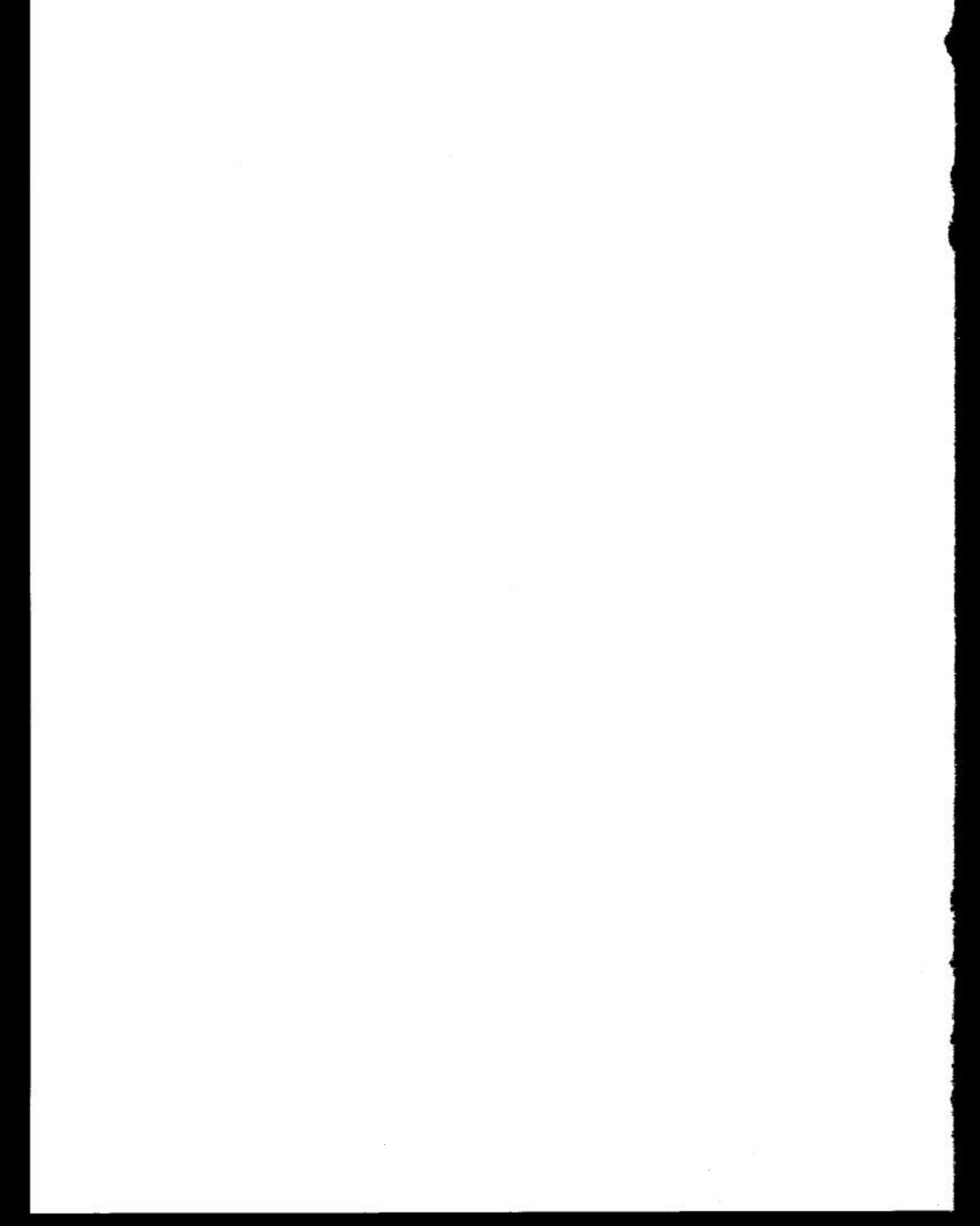
A surprising reduction in setting was achieved by the intensive noise reduction Field Changes made on each of the two sonars. These headsets gave 3/5 of that. Needless to say, at a bit less expense. The point is that we had overlooked an obvious inexpensively cured fault in our system while taking care of a needed expensive-to-cure fault — noise interference.

The next step is to get our STs to order the correct Navy headsets vice radiomen "di'da" monitors (if we can find them).

Oh, an indirect advantage; the commercial headset further helps in that external distracting noises are blocked (25dB down at 1000 hZ).

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\*U.S.N. Quarterly Information Bulletin, Summer, 1967.



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